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LIME-SULPHUR vs. BORDEAUX MIXTURE AS A SPRAY FOR POTATOES, II.

M. T. MUNN

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M. T. MUNN.

SUMMARY.

The experiment herein described is, in the main, a repetition of an experiment made in 1911. The results of the 1912 experiment agree essentially with those obtained in 1911. Plainly, the lime-sulphur solution is not to be recommended as a spray for potatoes. Six applications of bordeaux mixture prolonged the life of the plants about two weeks and increased the yield of marketable tubers at the rate of 111.5 bu. per acre; while rows receiving six applications of lime-sulphur died earlier, even, than the check rows.

Tipburn, and late blight (*Phytophthora infestans*) associated with and following which is the common rot of the potato tubers, were the chief diseases encountered in the experiment. Both were largely controlled by bordeaux. Lime-sulphur, on the contrary, dwarfed the plants and aggravated the tipburn, although, so far as could be determined, it did not burn the foliage. The effect of lime-sulphur on late blight and rot (*Phytophthora infestans*) is uncertain, but, apparently, it did not check them.

INTRODUCTION.

During the year 1911 an experiment designed to test the relative merits of lime-sulphur, lead benzoate, and bordeaux mixture, as a spray for potatoes, was conducted; and a detailed report upon it was given by F. C. Stewart and G. T. French in Bulletin No. 347 of this Station. It was deemed advisable to repeat this experiment during the past season along similar lines, but to omit the use of lead benzoate as it was conclusively shown that this material possessed no merits as a spray for potatoes.

OUTLINE OF EXPERIMENT.

PLAN.

The experiment field consisted of an area 212 x 51 feet which allowed 17 rows, each 212 feet long and 3 feet wide, each row thus containing approximately one sixty-ninth of an acre. After excluding a row on each side of the field as an outside row, there remained 5 series of rows with 3 rows in each series. Row No. 1 of each series was sprayed with bordeaux mixture, Row No. 2 with lime-sulphur and Row No. 3 was retained as a check. By this arrangement Rows 1, 4, 7, 10 and 13 were sprayed with bordeaux mixture, Rows 2, 5, 8, 11 and 14, with lime-sulphur. and Rows 3, 6, 9, 12 and 15 were not sprayed.

CULTURE OF CROP.

The slope of the field was sufficient to afford good surface drainage. The soil was a heavy clay loam. The field produced a crop of wheat the previous year and was plowed in the spring. Before planting, the area was harrowed twice. Seed of the variety Sir Walter Raleigh was planted by hand on May 24. Furrows were opened with a plow and the seed pieces placed 15 inches apart by the use of a gauge-rod. No fertilizer of any kind was applied at the time of planting. A horse cultivator was used during the season to keep the soil in good tilth. In addition to this, one light hoeing was given during the early summer. The cultivation, as a whole, was such as would be given a potato field on any well regulated farm.

PREPARATION OF THE SPRAY MIXTURES.

The concentrated lime-sulphur solution used was taken from a stock prepared for use in the station orchards, according to the Geneva Station Formula:

Lime (95 per ct. pure)	38 lbs.
Sulphur (high grade, finely divided)	80 lbs.
Water	50 gal.

This concentrate tested 24° Beaumé, and in order to reduce this mixture to the strength recommended for orchard spraying (1

to 40 when the density of the concentrate is 32° Beaumé), it was diluted at the rate of two gallons of the concentrate to fifty gallons of water.

The bordeaux mixture used was prepared from stock solutions and according to the 6–4–50 formula, thereby containing six pounds of copper sulphate and four pounds of unslaked lime in each fifty gallons.

The arsenate of lead used for the control of bugs was in the form of a thick paste and was used at the rate of three pounds to fifty gallons of the spray mixture, or to fifty gallons of water in the case of the check rows.

TIME AND NUMBER OF APPLICATIONS.

On July 9, when the plants were about six to eight inches high, the first application of the two sprays was given. This was repeated every two weeks until the vines were entirely dead. Six applications in all were made during the season.

In order to control the Colorado potato beetles or "bugs," arsenate of lead, at the rate of three pounds to fifty gallons of the spray mixture, was added and applied with the first two sprayings. On these same dates the check rows were sprayed with three pounds of arsenate of lead in fifty gallons of water. Following the first spraying it was found that the bugs were not as efficiently controlled on the lime-sulphur rows as they were on the other rows. The cause of this is uncertain, but was perhaps due to a lack of care in mixing the lime-sulphur and arsenate of lead. In order to control the bugs it was necessary to spray the entire field again in two days with three pounds of arsenate of lead in fifty gallons of water. This spraying and the addition of poison in the next regular spraying completely controlled the bugs for the entire season, and the use of a poison was thereafter discontinued.

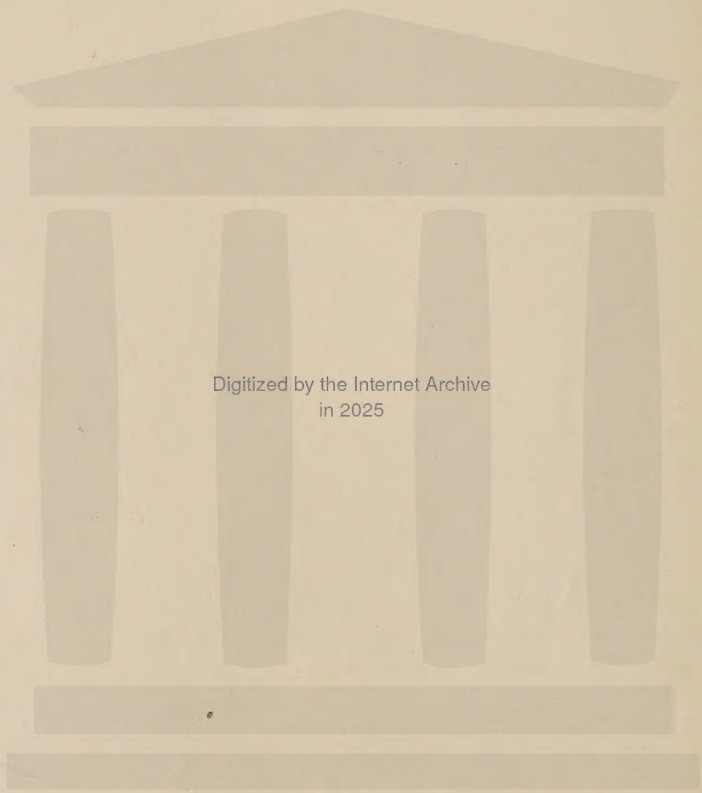
Both of the spray mixtures were applied with a knapsack sprayer, which permitted a very thorough spraying in every case. The rate of application varied from 150 to 200 gallons per acre, depending upon the size of the plants, and the season.

RESULTS.

EFFECT OF THE SPRAYS ON THE FOLIAGE.

In addition to the desirability of testing the value of lime-sulphur as compared with bordeaux as a preventive of potato blight (*Phytophthora infestans*) it was one of the objects of this experiment to determine the effect of the two preparations on the foliage. At short intervals during the season notes were taken upon the condition of the foliage in the experimental field. The weather following planting was such as to induce a satisfactory growth, and at the end of the sixth week the plants were about eight inches high, in full foliage, even all over the field, and growing vigorously. At this time, July 9, the first application of the spray mixtures was given. Previous to the third spraying all the rows looked very uniform in size and color of foliage, but on August 6, following the third spraying, more yellow and dead leaves were noticed on the lower branches of the plants in the lime-sulphur rows and the check rows, than on the bordeaux rows, which, with the exception of an occasional dead leaf, were entirely free and presented a vigorous appearance. Flea-beetle injury, while very slight, was more prevalent on the lime-sulphur and check rows than on the bordeaux rows, no doubt due to the deterrent properties of the bordeaux. About August 16 tipburn appeared and continued to increase gradually in extent upon the lime-sulphur rows and the checks until the end of the season. The bordeaux rows were nearly free from it during the entire season while on the lime-sulphur rows it appeared as if the trouble was aggravated by the lime-sulphur spray. A large percentage of the plants in the lime-sulphur rows were completely dead from the effects of the tipburn several days before many plants had died in the check rows. It cannot be stated that this trouble called tipburn was due to insufficient moisture owing to the fact that it appeared more destructive during the latter part of the season and at a time when rains were frequent, often preventing cultivation for several days. It also appeared more destructive on the north half of the field which was slightly lower than the south half of the field.

PLATE I.—VIEW FROM SOUTH END OF EXPERIMENTAL FIELD ON SEPTEMBER 27.
Bordeaux rows in full foliage; lime-sulphur rows entirely dead; check rows nearly dead.



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On August 20, attention was attracted to the slightly smaller size of plants in the lime-sulphur rows as compared with those in the bordeaux rows and the checks. This difference became quite marked on August 25 when it could be plainly seen that the plants in the lime-sulphur rows were smaller in size, not as spreading or bushy, and the stems appeared smaller, when compared with plants in the other rows. This difference was noticeable throughout the remainder of the season.

On September 3, late blight (*Phytophthora infestans*), which caused much tuber rot later in the season, was found to be prevalent in a nearby potato field, but it did not appear in the experimental field until September 25 when it was found on the check rows upon a number of living plants that still remained in those rows, and also upon the few living plants that still remained in the lime-sulphur rows. The number of living plants was considerably smaller in the lime-sulphur rows than in the check rows. All of the plants then alive in both rows were soon killed by the combined attack of the tipburn and the blight.

The late appearance of the Phytophthora blight in the field was perhaps due to the somewhat small growth of potato foliage caused by a lack of fertility in the soil. In nearby potato fields the foliage blight was prevalent and followed by a severe rotting of the potato tubers. A very little early blight (*Macrosporium solani*) occurred in September.

The superior condition of the bordeaux rows first became apparent about August 20 and the difference became conspicuous during the latter part of the season. On October 17, the date upon which they were harvested, the bordeaux rows still contained several living plants. They outlived the lime-sulphur and check rows over two weeks.

YIELDS.

The following table shows the kind of treatment, also the yield as determined by carefully sorting and weighing each row separately at the time of digging.

TABLE I.—COMPARATIVE YIELDS OF POTATOES SPRAYED WITH LIME-SULPHUR AND BORDEAUX MIXTURE.

Row No.	Kind of treatment.	Yield per row.			Computed yield per acre.			
		Marketable tubers.	Small tubers.	Rotten tubers.	Marketable tubers.	Small tubers.	Rotten tubers.	Total yield.
		Lbs.	*Lbs.*	*Lbs.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
1	Bordeaux	217.5	10.0	1.0	246.6	11.4	1.1	259.1
2	Lime-sulphur	148.0	17.0	9.0	168.9	19.4	10.2	198.5
3	Check	137.5	10.0	64.5	156.9	11.4	73.9	242.2
4	Bordeaux	283.5	9.0	8.0	323.6	10.2	9.1	342.9
5	Lime-sulphur	154.0	5.5	44.5	175.8	6.2	50.8	232.8
6	Check	163.5	7.0	86.0	186.6	7.9	98.1	292.6
7	Bordeaux	276.0	5.0	6.0	315.1	5.7	6.9	327.7
8	Lime-sulphur	166.0	5.5	16.5	189.5	6.2	18.8	214.5
9	Check	134.5	6.0	88.0	153.5	6.9	100.4	260.8
10	Bordeaux	236.0	4.0	5.0	269.4	4.5	5.7	279.6
11	Lime-sulphur	152.0	5.5	18.0	173.5	6.2	20.5	200.2
12	Check	148.5	5.0	51.5	169.5	5.7	58.7	233.9
13	Bordeaux	200.0	6.0	0.0	228.3	6.9	0.0	235.2
14	Lime-sulphur	131.0	10.0	1.0	149.5	11.4	1.1	162.0
15	Check	140.0	9.0	4.0	159.0	10.2	4.5	173.7

TABLE II.—SUMMARIZED YIELDS OF POTATOES SPRAYED WITH LIME-SULPHUR AND BORDEAUX MIXTURE.

Kind of treatment.	Average yield per acre.			
	Marketable tubers.	Small tubers.	Rotten tubers.	Total.
	Bu.	*Bu.*	*Bu.*	*Bu.*
Bordeaux mixture	276.6	7.7	4.5	288.8
Lime-sulphur	171.4	9.8	20.3	201.5
Check	165.1	8.4	67.1	240.6

Gain from use of bordeaux 111.5 bu. marketable tubers per acre.
Gain from use of lime-sulphur, 6.3 bu. marketable tubers per acre.
Gain from use of bordeaux, 48.2 bu. in total yield per acre.
Loss from use of lime-sulphur, 39.1 bu. in total yield per acre.

Although showing a considerably smaller total yield, the lime-sulphur rows gave a slightly larger yield of marketable tubers than did the check rows. This is due to the smaller loss from rot on the lime-sulphur rows. This was only 20.3 bushels as

against 67.1 bushels per acre on the check rows. One unfamiliar with the experiment might draw the conclusion that lime-sulphur has some value as a preventive of tuber rot. However, the facts in the case do not warrant such a conclusion. The correct interpretation seems to be as follows: There was less tuber rot on the lime-sulphur rows because at the time blight attacked the field there were fewer live plants on these rows. Many were already dead and incapable of taking blight, consequently they were incapable of transmitting the disease to the tubers. On the check rows there were more living plants for the disease to attack. Such plants as were still alive on the lime-sulphur rows seemed to be quite as severely attacked as those on check rows, but the data on this point are insufficient for definite conclusions.

It is also worthy of note that all the rotten tubers on the bordeaux rows were found in a slight depression at the north end of the field, where the surface water from rains flowed across the rows and undoubtedly carried spores from the adjoining infected rows. No blight was found upon plants in the bordeaux rows at any time during the season.

There was a marked difference in the size of the tubers from the rows under different kinds of treatment. Tubers from the bordeaux rows were somewhat larger than those from the check rows and considerably larger than those from the lime-sulphur rows.

It is not strange that the lime-sulphur rows gave a lower yield than the check rows when one considers the dwarfed condition of the plants in those rows and the fact that a great many of the plants were dead several days before those in the check rows.

Although blight did not appear until late in the season after a large percentage of the plants had died, so that the amount of foliage affected was not large, the severity of the tuber rot is surprising. It is evident that under favorable weather conditions a small amount of blight may cause a heavy loss from tuber rot.

CONCLUSIONS.

The information at hand is quite sufficient as a basis for some final conclusions. It seems evident that lime-sulphur is not destined to take the place of bordeaux mixture as a spray for potatoes, in spite of the fact that it is cheaper and no doubt very convenient to use. Under more favorable conditions, in which late blight occurred earlier in the season and to a greater extent, the treatment with lime-sulphur might have produced different results, but at present it is not promising. However, the experiments have not been carried far enough to determine what may be expected under favorable conditions.

The lime-sulphur proved harmless to the potato foliage as far as burning is concerned, but it proved to have a distinct dwarfing effect quite similar to that noted in the previous season's experiment. The lime-sulphur also lacked the beneficial or stimulative effect derived from the bordeaux mixture which preserved the foliage and prolonged the life of the plants and thereby increased the yield even in the partial absence of fungus diseases.

It could not be determined at just what time in the season or after which application the dwarfing effect of the lime-sulphur first occurred, but it was first noticeable on August 20 at the time of the fourth spraying, and on August 25 following this spraying it became quite marked. It therefore appears that the injury is cumulative. The benefical effect of the bordeaux on the foliage was observed on August 6 or approximately two weeks before the injurious effect of the lime-sulphur was noticed, when it was plainly evident that there were many yellow and dead leaves on the lower branches of plants in the lime-sulphur rows and in the check rows while there were practically none on the bordeaux rows which held their foliage throughout the season.

In general, then, we are led to the same conclusions published in last year's bulletin on a similar experiment, namely, that spraying potatoes with bordeaux mixture increases the yield of tubers and prolongs the life of the plants; while the use of lime-sulphur dwarfs the plants, causes them to die earlier, and causes an appreciable loss in yield. Certain it is that spraying potatoes with bordeaux mixture should not be omitted by the potato grower.